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INSECT CONDITIONS IN THE NEBRASKA NATIONAL FOREST (EXCLUSIVE OF PITCH MOTHS) DURING 1932, INCLUDING A SUMMARY OF TREE PLOT RECORDS AS COMPARED TO TIP MOTH PARASITISM

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INSECT CONDITIONS IN THE NEBRASKA NATIONAL FOREST (EXCLUSIVE OF PITCH MOTHS) DURING 1932, INCLUDING A SUMMARY OF TREE PLOT RECORDS AS COMPARED TO TIP MOTH PARASITISM

This report summarizes data and observations on the more important insects in the plantations of the Bessey Division of the Nebraska National Forest and Bessey nursery, near Halsey, Nebraska, for 1932 as compared to previous years - excepting the pitch moth situation which is covered in a separate report. The infestation by the two species of pine tip moths and the progress of the introduced parasite are reviewed. This parasite was introduced into three private plantations during the summer and the record of these colonizations are given with a discussion of methods used in handling the parasite and the success of trial shipments of adults to the Gipsy Moth Laboratory at Melrose Highlands, Mass. The data from plots of different tree species are summarized, showing the annual height growth and amount of tip moth infestation over a period of 7 and 8 years and the recovery made by the trees following the effective work of the introduced parasite. Counts on grasshopper population were made to determine the mortality from the extensive control operation carried out by the Forest Service in June. The white grub situation in the nursery is reviewed, including the life cycle of the more common May beetle and some earlier preliminary tests for control.

The work was carried on with the cooperation of the Forest Service as in past years. The studies on the Nebraska project in 1932 were limited to the period between June 20 and August 15, a somewhat shorter period than usual, and the work was conducted this year without the aid of a regular field assistant.

PINE TIP MOTHS AND PARASITES

It might be well to briefly mention again the history of the two destructive tip moths occurring in the pine plantations. Rhyacionia frustrana bushnelli (Busck), which is the smaller of the two species and has two complete generations each season, was first discovered present in 1909 and for 20 years, or until after the introduction of parasites, destroyed many of the new growth shoots. Rhyacionia neomexicana (Dyar), which has but a single generation ending in early July, evidently came into the area years later, was first observed in 1926, and not until about 1929 was damage by this species very noticeable. The parasite, Campoplex frustranae Cushman, introduced from Virginia in 1925, proved very effective against the first or original species of tip moth, but it seems to be unable to develop in the second species.

Rhyacionia frustrana bushnelli (Busck).

The first field counts on June 21, 1932, showed that about 60% of the spring generation larvae of R. bushnelli had already pupated in the infested tips. The earliest moth emergence was noted on June 27, indicating nearly a normal season compared to the past seven years, being five days later than the earliest season in 1926 and seven days ahead of the most delayed season of 1927. The annual collection of infested tips was made at this time for caging in the laboratory and recording the daily emergence of moths and parasites. A total of 2400 ponderosa pine tips were taken from eight collection plots scattered across the plantations, including one in the camp 4 area. Insects emerged from the parasite cages during the remainder of June and through July and the final figures on number of moths and parasites indicate the per cent of parasitism. Before discussing the

amount of parasitism, the progress of the introduced parasite from the time of its introduction will be reviewed briefly. This applies to Campoplex frustranae since the few other introduced parasites which became established, as recorded in last year's report, are of no importance and many never prove to be of any particular benefit.

Campoplex frustranae Cushman

This parasite was originally colonized in 1925 at a single point in the plantations, the release plot being located about a half mile southwest of the nursery on the Halsey-plantation road. The planted area at that time extended from this plot continuously for about 1½ miles to the east, 4 miles to the west, 5 miles to the southwest, ½ mile to the nursery on the north, and a mile to the south. Farther to the south a smaller isolated planting area at Camp 4 occurred, being separated by a strip 1½ miles wide from the older plantations - part of this isolation strip being planted in the last few years. The total area covered by plantations in 1925 was nearly 12,000 acres, at present 16,000 acres being the gross area on the Bessey Division of the forest.

In the vicinity of where first liberated, Campoplex increased the low native parasitism of 10% to about 83% by 1929 and reduced the infestation proportionately as will be shown later in the tree plot studies. During the four years required for its spread to the west side of the plantations, parasitism varied directly with the distance from the original point of colonization. The parasite also reached the isolated area at Camp 4 to the south by 1929. In 1930 parasitism was high in all parts of the plantations, and in plots 2 miles or more from the release plot, averaged from 80% to over 90%. However, in this same year the abundance of Campoplex was already dropping off near the original release area due to a scarcity of host material. In 1931 there was a sudden drop in the numbers of this

parasite in all areas and it appears that certain external conditions, probably the exceptionally dry and open winter, had been detrimental to Campoplex. This decrease in parasitism resulted in an immediate increase of tip moths for the next generation.

In 1932 Campoplex showed a marked recovery which brought a rise in the average per cent of parasitism; however, this increase was confined largely to the more distant plantations. The average number of moths and parasites emerging from tips taken from eight collection plots during the last three years, after Campoplex was well distributed over the entire area, is presented in Table 1. This shows the marked decrease in the Campoplex population in 1931 and the responding fluctuation in number of moths emerging. The apparent increase in numbers of local or native parasites is due to the annual variation of one or two species but can not be considered permanent.

Table 1. Average number of tip moths (Rhyacionia bushnelli) and parasites emerging for each 100 infested tips, and per cent parasitism for all plots, 1930 to 1932; based on 2400 ponderosa pine tips each year.

Year	Total no. of all insects	No. of moths	No. of introd. Campoplex	All local parasites	Parasitism
1930	88.5	15.9	64.6	8.0	82%
1931	116.5	66.5	38.8	11.2	43%
1932	141.7	73.6	54.0	14.1	48%

The figures given in Table 1 are based only on first generation insects but it has been found that they portray very well the trend of infestation and parasitism. The necessity of holding second generation material over winter and rearing under artificial conditions makes similar data for this generation inaccurate. The total number of insects, in the

second column, indicates the abundance of larvae in the tips - most of them completing their feeding before being destroyed by parasites. The number of moths emerging to produce the progeny for the summer generation gives a relative indication of the amount of damage that might be expected by this second generation.

In comparing the separate collection plots for the 1932 season, it was quite striking that for the original Campoplex release plot and two plots about a mile distant, Campoplex showed little or no increase in numbers over 1931, regardless of the somewhat more numerous host; parasitism averaging only 19% for these three plots. While at distances of two or more miles the parasite showed a considerable increase, parasitism averaging 48% for the five more distant plots. This difference was apparent but less evident the year previous and at that time was attributed to the variation in abundance of host material, and the fact that trees in nearby areas had made a much better growth, were larger and thus made the search for the more scattered larvae difficult. With the greater variation recurring in 1932 it appears that there are other influencing factors.

It seems significant that the area in which Campoplex is deficient corresponds to that part of the plantations where the second species of tip moth, Rhyacionia neomexicana, is now very plentiful; this species being relatively scarce in the more distant plantations. Campoplex has never been definitely reared from this moth and in the field it is evident that the parasite has not checked the multiplication of this pest. It had been assumed that either the larvae were not attacked or that development in this host was impossible. Now it seems probable that Campoplex is ovipositing in R. neomexicana, being unable to distinguish between the young larvae of the two species, but because of certain physiological conditions

in this host the parasite is destroyed. Thus, Campoplex would be decreasing its reproductive potential, and this would explain why in areas where R. neomexicana is numerous it is failing to respond to the upward fluctuation of its less numerous original host, R. bushnelli.

From the separate Niobrara Division of the forest in the northern part of the State, where Campoplex frustranae was introduced and established in 1929, Supervisor Nelson collected infested tips in late June, 1932. In transporting or shipping these green tips to Halsey in insect proof bags, it is probable that some of the parasites may have been injured or destroyed by heating, as appeared to be the case in a shipment in 1931. Consequently, the figures on parasitism may not be accurate. The 1932 rearings showed a total parasitism of 28% in plantations around the Ranger station, and only 8% in the separated area at the planting camp. These figures are slightly higher than for the year previous. There has been no opportunity to check recent field conditions on the Niobrara Division.

Rhyacionia neomexicana (Dyar)

This moth at the present time is unevenly distributed over the Bessey Division of the forest. It is causing serious damage in the northeastern part of the planted area, particularly within a half mile radius from the nursery. Larvae have been found in all parts of the plantations but in the more distant areas the species is still comparatively scarce and evidently it is not spreading rapidly from the center of heavy infestation. Counts were again made of infested leaders on ponderosa pine at several points within a mile of Block IV of the nursery. These figures are compared in Table 2 to similar counts in 1930 and 1931 and show how the infestation decreases with distance from the north boundary at the nursery, and also

indicate the multiplication that has occurred at the same locations in the last two years. The trees at the three points average about the same height, being planted in 1913 or 1915.

Table 2. Per cent of ponderosa pine leaders infested by Rhyacionia neomexicana and average number of larvae per infested leader in a plantation on the hill above Block IV of the nursery and at half-mile intervals to the southwest, 1930 to 1932.

Year	No. leaders exam. at each point	Near nursery		½ mile S. W.		1 mile S. W.	
		% inf.	No. larvae	% inf.	No. larvae	% inf.	No. larvae
1930	200	76	-	19	-	-	-
1931	300	75	4.8	38	2.2	-	-
1932	200	93	6.0	79	4.0	19	1.9

The counts at a half mile from the nursery were made near the original Campoplex parasite release plot and the increase of the moth here is rapidly offsetting the benefit of the parasite in controlling the other species of tip moth, as will be evident from the tree plot data shown later. The low infestation a mile distant is not representative of some areas to the west of this point; later counts in a tree plot 1½ miles west of here indicating about 33% of the leaders infested by R. neomexicana in 1932. However, at greater distances, in the Camp 3 and Camp 4 planting areas the species is still scarce.

In the same leaders shown in Table 2, for 1932, the first generation larvae of the smaller moth, R. bushnelli, were recorded as infesting 23% in the plantation above the nursery, 17% near the Campoplex plot ½ mile to the southwest, and 38% in the area 1 mile from the nursery. Some of these tips were infested by both species. The injury to individual tips by first generation R. bushnelli is always light compared to that caused by the more

abundant second generation, and is much less than damage by the single generation of R. neomexicana which not only has larger larvae but seems to be more numerous in the infested shoots, presumably because the eggs are laid in groups by the latter species.

TREE PLOT RECORDS

In 1925 and 1926 a large number of plots containing about 100 trees each were staked out for a study of tip moth infestation in different species of pine of various ages. A record has been taken each fall on some of these plots, showing the amount of height growth, per cent of leaders and in some cases per cent of lateral shoots infested, and the proportionate amount of each individual leader destroyed. Although not all of these plots are properly located for an ideal study of the progress of the introduced parasite which developed later, and parasite collections have not been made at all of these points, nevertheless, they serve very well to demonstrate the reduction in infestation and the recovery in growth made by the trees. This added height growth has been particularly apperent in an area within a radius of 1½ miles from the original Campoplex release plot, where two or more consecutive years of heavy parasitism occurred. The per cent of leaders infested furnishes a good index to amount of infestation since it has been found to correspond to the total per cent of tips attacked on all trees - the per cent of all lateral tips infested always running a little lower than per cent of leaders infested. Parasitism in the different areas is discussed in connection with each plot.

Three ponderosa pine plots are given below, one adjacent to the Campoplex parasite release plot, one at 2 miles distance, and a third at 3¾ miles in comparatively young trees. Two plots in Norway pine and one in

jack pine, all within the area of heaviest parasitism, are also given for comparison of height growth. The trees in the older ponderosa and Norway pine plots had been held back for years by repeated destruction of a large portion of the leaders, a few of these trees being less than two feet tall after 10 or more years in the field, while more vigorous individuals had made a small or fair growth rate each year. The recovery in the Norway pine plots has been remarkable, following the reduction of tip moth infestation.

Several points should be mentioned for consideration with the tables of growth and infestation given below. The height of the tree, measured to the base of the terminal bud, includes the total length of the leader regardless of how much of this was killed back by tip moth, therefore, growth for the following year is largely influenced by the severity of this infestation, the new growth either originating below the point of injury or developing from a lateral shoot. This subsequent poor growth is apparent in all plots in 1927, in spite of above normal rainfall, following the very severe damage occurring in 1926. In 1931 the lessened rate of growth is due to serious drought conditions of that year. The infestation as shown includes both generations of Rhyacionia bushnelli. The number of leaders recorded as infested by R. neomexicana include only those attacked by this species alone and where there was evidence that both tip moths infested the shoot it was recorded under R. bushnelli for a better comparison of the latter species over the entire period - the per cent ordinarily attacked by both species is small and if segregated would add from 1 to 10% to the number infested by R. neomexicana, depending on amount of infestation. When no tree mortality is mentioned all trees have survived during the period of observation, and the loss noted in some plots is due to causes other than tip moth - gophers, grasshoppers, and natural

loss in new plantings. Density of stand is not a factor in these plots, and all except the youngest ponderosa pine plot were of a highly susceptible age and height.

In Table 3 is given the record of a ponderosa pine plot adjacent to the place where the parasite, Campoplex frustraneae, was originally released in 1925, consequently, this is in the locality that has benefited from the parasite for the longest period. Parasitism, reached a high point of 83% here in 1929 and continued high in 1930 to reduce the infestation by R. bushnelli still further, although this decrease in 1930 was offset by R. neomexicana. Maximum height growth occurred in 1930, resulting from the large number of uninfested leaders remaining from the previous year for normal growth. The average growth for the 100 trees in that year was nearly 11 inches, some of the trees having leaders 15 to 19 inches long. Had it not been for the drought in 1931, growth probably would have exceeded this maximum.

Table 3. Average annual height growth and per cent of leaders infested by tip moths adjacent to original Campoplex parasite release plot, 1925-1932, in a plot of 100 ponderosa pine planted in 1915 as 2-1 stock; trees 13 years old in 1925. Plot No. 19 located in plantation No. P-125 (16a).

Year	Average height in inches	Increase in height over prev. year	% leaders infested by both species	% leaders infested by R. bushnelli	% additional leaders inf. by R. neomexicana
1925	37.3	5.3	86	86	0
1926	44.6	7.3	92	92	0
1927	47.9	3.3	88	88	0
1928	54.1	6.2	69	69	?
1929	61.7	7.6	33	27	5
1930	72.5	10.8	29	15	14
1931	80.6	8.1	63	35	28
1932	87.4	6.8	91	26	65

It is evident from Table 3 that the growth rate in the plot for the last four years was above the previous average, in spite of the 1931 drought and the increasing damage caused by R. neomexicana. Average height growth in the last four years totaled 33.3 inches or a 50% increase over the 22.1 inches made during the preceding four years; and equals 38% of the total average height of the trees in 1932.

A second ponderosa pine plot located 2 miles west of the point of liberation for Campoplex is given in Table 4, the trees being 3 years younger than those in the plot above. The parasite had spread into this area by 1928, three years after introduction, and by 1930 a maximum parasitism of over 90% for the first generation was recorded in this locality. Although in 1929 the per cent of leaders attacked appears high, the infestation was more scattered and damage to individual tips lighter, with the result that growth tne following year was considerably above the average. The high parasitism in 1930 caused considerable decrease in infestation by R. bushnelli, however, this is not in proportion to the more than 90% parasitism because the first generation larvae were numerous enough to hold the infestation for the season fairly nigh. Growth in 1931 was influenced by drought. It was expected that parasitism would remain high in 1931 and reduce this tip moth still further, judging from the preceding plot, but Campoplex made an unexpected drop that year, as discussed previously, with the result that R. bushnelli built up sufficiently for the second generation to even raise the per cent of leaders injured. It can be seen from this that unless parasitism is maintained at a high point for two or more consecutive years, the infestation by R. bushnelli is not reduced to a minimum and the trees can not make a normal recovery. In 1932 Campoplex multiplied sufficiently in this locality to be beneficial but here again this is

being offset by the increase of R. neomexicana. The partial reduction in infestation caused by the parasite in this plot has, nevertheless, resulted in a growth during the last three years which is 66% above the previous three-year average.

Table 4. Average annual height growth and per cent of leaders infested by tip moths 2 miles west of Campoplex release plot, 1925-1932, in a plot of 100 ponderosa pine planted in 1918 as 2-1 stock; trees 10 years old in 1925. Plot No. 13 located in plantation No. P-177x.

Year	Average height in inches	Increase in height over prev. year	% leaders infested by both species	% leaders infested by: R.bushnelli	% additionel leaders inf.by R. neomexicana
1925	22.2	2.5	81	81	0
1926	29.2	7.0	97	97	0
1927	31.6	2.4	97	97	0
1928	36.2	4.6	86	86	0
1929	42.7	6.5	84	84	7
1930	51.7	9.0	72	68	4
1931	59.4	7.7	82	73	9
1932	65.1	5.7	91	67	24

The data on a third ponderosa pine plot, established in very young trees and located 3½ miles southwest of the Campoplex release area is given in Table 5 below. It has been found that tip moth infestation builds up gradually over a period of six or seven years in new plantations continued at the border of recent plantings, as is well illustrated in this plot. Height measurements in trees of this size are somewhat influenced by filling in or washing of the planting furrows the first year or two; however, it is evident that these young trees made a fairly normal increase in growth rate until after more than 50% of the leaders were being damaged.

Campoplex probably spread into this area in considerable numbers early in 1929 and in several generations built up parasitism to about 80%, in 1930. The infestation, which was just reaching its peak at that time, was reduced somewhat. The abnormal decrease of Campoplex in 1931, dropping parasitism to nearly 40% in spite of a fair amount of host material remaining in this area, permitted R. bushnelli to more than recuperate its losses. With Campoplex abundant for only one season the trees did not have a chance. It is encouraging, however, to see the recovery made by Campoplex in 1932 in these outlying areas, parasitism jumping to about 90% with a sharp drop in infestation as indicated for this year in the table below. With R. neomexicana remaining scarce these trees should be making rapid growth in the next two or three years.

Table 5. Average annual height growth and per cent of leaders infested by tip moths 3½ miles southwest of Campoplex release plot, 1925-1932, in a plot of 109* ponderosa pine planted in 1924 as 2-1 stock; trees 5 years old in 1925. Plot No. 1 located in plantation No. P-223B.

Year	Average height in inches	Increase in height over prev. year	% leaders infested by both species	% leaders infested by: R. bushnelli	% additional leaders inf. by R. neomexicana
1925	4.7	-	1	1	0
1926	6.6	1.9	5	5	0
1927	9.2	2.6	13	13	0
1928	14.9	5.7	58	58	0
1929	18.2	3.3	90	90	0
1930	22.0	3.8	78	78	0
1931	25.2	3.2	96	95	1
1932	27.0	1.8	59	59	0

*(Tree mortality: 2 in 1926; 2 in 1927; 3 in 1928; 1 in 1929; 1 in 1930; 4 in 1931; 0 in 1932. Loss in 1929 and 1931 due to grasshopper girdling which also caused destruction of a number of leaders. Other mortality due to natural loss in young trees and not caused by tip moth. Survival in 1932, 88%).

Norway pine is damaged as severely by the tip moth as is ponderosa pine and undoubtedly this pest is largely responsible for the poor showing made in the early plantations of this species which was discontinued for use in planting. The ability of Norway pine to make rapid height growth in the sandhill region of Nebraska, if released from insect damage, is quite apparent from the following plot studies. Table 6 illustrates the recovery made in a plot of old Norway pine located only ¾ of a mile from the point where Campoplex was originally released. The data only continue to 1931, and since the plot was not checked each year, growth was measured back for periods missed. Campoplex was recorded in this plantation in the spring of 1927 and a noticeable increase in the height was made the following year. Parasitism was probably heaviest during 1929, judging from other areas, and the added growth rate in 1930 is apparent. Drought is probably the cause of less height made in 1931.

Table 6. Average annual height growth and per cent of leaders infested by tip moths ¾ mile southeast of Campoplex release plot, 1925-1931, in a plot of 100 Norway pine planted in 1910 as 2-2 stock; trees 19 years old in 1925. Plot No. 17 located in plantation No. P-45-8.

Year	Average height in inches	Increase in height over prev. year	% leaders infested by both species	% leaders infested by R. bushnelli	% additional leaders inf. by R. neomexicana
1925	40.8	4.7	-	-	-
1926	50.1	9.3	96	96	0
1927	51.0	1.0	83	83	0
1928	56.3	5.3	-	-	-
1929	69.1	12.8	-	-	-
1930	87.3	18.2	30	25	5
1931	101.9	14.6	50	26	24

In the Norway pine plot shown above, growth during the last three-

year period, 1929-1931, when the parasite had most effectively reduced the infestation, totaled 45.6 inches or an increase of 192% over the 15.6 inches made during a similar period immediately preceding. In 1925, these trees averaged only 40.8 inches in height at the age of 19 years, 15 years after planting, consequently the growth in the last three-year period exceeded by five inches that made in the first 19 years.

A second Norway pine plot is given in Table 7, in trees six years younger than the above plot but the same age as the first ponderosa pine plot shown in Table 3. The location is 1½ miles west of the Campoplex release area and the parasite probably spread into the plantation either late in 1927 or early in 1928 and multiplied rapidly to a high point in 1930. The trees showed the first recovery in 1930 in response to more normal leaders remaining from the year previous. This response was a year later than in the plot above because of the greater distance from the Campoplex release area, the parasite coming in about a year later. In 1931 in spite of drought the trees again made the same amount of growth as a result of further reduction in damage from the previous year. The partial failure of Campoplex in 1931 did not result in a sudden increased tip moth infestation in either of the Norway pine plots, such as evidenced in ponderosa pine, however, by 1932 there was a considerable increase. It is possible that with the added vigor in Norway pine the trees are developing some resistance to tip moth larvae.

Table 7. Average annual height growth and per cent of leaders infested by tip moths 1½ miles west of Campoplex release plot, 1925-1932, in a plot of 100* Norway pine planted in 1915 as 2-1 stock; trees 13 years old in 1925. Plot No. 20 located in plantation No. P-119 (10c).

Year	Average height in inches	Increase in height over prev. year	% leaders infested by both species	% leaders infested by: R. bushnelli	% additional leaders inf. by R. neomexicana
1925	26.8	3.7	-	-	-
1926	32.9	6.1	96	96	0
1927	36.7	3.8	100	100	0
1928	40.4	3.7	97	97	0
1929	46.5	6.1	67	67	0
1930	59.4	12.9	19	19	?
1931	71.9	12.5	20	16	4
1932	86.9	15.0	57	48	9

*(Survival in 1932, 96%. Mortality in this plot caused by pocket gophers feeding on the roots. Loss as follows: 1 tree in 1928, 2 in 1939; and 1 in 1930).

Following control by the parasite, the Norway pine shown in Table 7 above made a height growth in the last three years of 40.4 inches, a 194% increase over the growth of 13.6 inches made during the previous three years; or equal to 46.5% of the total average height of the trees in 1932 at 20 years of age. This last three years of height growth for the plot just equals the average height attained by these trees during their first 16 years, to the end of 1928.

One plot in jack pine is presented in Table 8 and even though the trees are young compared to most of the other plots, it serves to show the rapid growth made by this species. The plantation is not far from the nursery and was put out to replant a small area surrounded by old ponderosa pine, consequently, the tip moth has heavily infested these trees from the time of planting which is not typical of outlying plantations where the in-

sect builds up gradually for a period of years. Early growth is, therefore, probably below average. Jack pine not only is less heavily infested than ponderosa and Norway pine, ordinarily, but overcomes injury to leaders by replacement with one of the numerous current laterals and a rapid development of adventitious buds. Although this plantation was making fair growth with injury probably above normal for jack pine, it is evident from the plot data that when infestation is decreased a decidedly greater height is added, as occurred in 1930. This plot is only 3/8 mile from the Campoplex plot and parasitism was probably greatest in 1929 and 1930. Drought undoubtedly influenced growth in 1931, the last year of recorded data, and in this year the tip moth, R. bushnelli, increased as a result of the drop in numbers of Campoplex. R. neomexicana is also attacking jack pine but not as heavily as the other tree species.

Table 8. Average annual height growth and per cent of leaders infested by tip moths 3/8 mile east of Campoplex release plot, 1925-1931, in a plot of 100* jack pine planted in 1921 as 2-0 stock; trees 6 years old in 1925. Plot No. 16 located in plantation No. P-209B.

Year	Average height in inches	Increase in height over prev. year	% leaders infested by both species	% leaders infested by: R.bushnelli	% additional leaders inf.by R.neomexicana
1925	27.6	8.4	-	-	-
1926	40.4	12.8	96	96	0
1927	51.5	11.1	87	87	0
1928	67.1	15.6	84	84	0
1929	81.6	14.5	30	30	?
1930	105.5	23.9	35	30	5
1931	123.4	17.9	79	68	11

*(One tree dying in 1931, probably windthrown during sleet or heavy snowstorm in winter).

SUMMARY OF EFFECT OF PARASITISM ON TREE GROWTH

Some of the main points brought out from the study of tip moth parasitism in its relation to tree growth in the plantations of the forest, as indicated by the tree plots, can be summarized as follows:

Where a substantial reduction in infestation was maintained for two or more consecutive years the trees responded with a marked acceleration in height growth. The infestation by Rhyacionia frustrana bushnelli was reduced as parasitism increased, which was due almost entirely to the introduced parasite, Campoplex frustranae, and is correlated directly with the spread of this parasite.

Trees within a radius of about 1½ miles from the original point of Campoplex liberation have shown the most decided recovery because of the longer period of parasite protection. This recovery is perhaps even more apparent when seen in the field than from the plot data presented above, if the present form and character of particularly ponderosa and Norway pine are visually compared to their degenerate condition only five years ago. However, in part of this highly protected area considerable damage is being done at the present time by the other species of tip moth, Rhyacionia neomexicana, upon which the parasite apparently has no influence.

In plantations 2 or more miles from the original Campoplex release plot, much less recovery was made by the trees because parasitism was high for only one season, 1930, Campoplex taking an abnormal drop in 1931. In the more distant plantations in 1932, parasitism of R. bushnelli was again high and if Campoplex continues at a normal rate of increase in the next couple of years these areas, where R. neomexicana is still scarce, will show the greatest acceleration in height growth.

Considering the most normal growth made by the different species of pine; the ponderosa pine plot, planted in 1915, made an average of

nearly 11 inches height growth in 1930. This might have been exceeded in 1931 had it not been for drought conditions, and the influence since that time of the influx of R. neomexicana. If insect damage could be continously reduced it is believed that ponderosa pine on the better sites would average over a foot of height growth a year, after being well established, some trees adding from 1½ to 2 feet a year.

In the Norway pine plot planted in 1915 the greatest growth rate was an average of 15 inches per tree for the plot; in the old 1910 planting the average was over 18 inches for one year. It appears that the normal growth rate of Norway pine in the sandhill region, with the tip moth sufficiently reduced, will exceed that of ponderosa pine. The recovery already shown by Norway pine has resulted in the renewed use of this species for a small part of the planting stock.

Jack pine, although making good growth and not as severely injured, adds considerable height when tip moth infestation is reduced. The trees in the jack pine plot averaged 24 inches in height growth in 1930, at 11 years of age and 9 years after field planting, some leaders being nearly 3 feet in length.

Scotch pine and Austrian pine have not been discussed because they are less effected by tip moth and very little growth data have been taken. Scotch pine is damaged to some extent but less so than jack pine; it puts on a good annual growth somewhat comparable to, but probably under that of the latter species. Austrian pine is almost immune to tip moth injury, only occasionally are leaders infested. This species makes a fair growth, approximating that of the more normal ponderosa pine.

PARASITE INTRODUCTIONS IN PRIVATE PLANTATIONS

During July, 1932, considerable time was spent in accumulating quantities of the parasite Campoplex frustranae Cush. for introduction into several private pine plantations in Nebraska, as well as for some trial shipments to the Gipsy Moth Laboratory in Massachusetts as will be discussed later. Some of the introductions were undertaken at the request of and in cooperation with the State Extension Forester, Clayton W. Watkins, to aid in the control of the tip moth, Rhyacionia frustrana bushnelli, which is seriously injuring practically all of the small plantations put out on the farms or ranches in Nebraska. The adult parasites were reared at Bessey Nursery on the forest and transported to the place of colonization rather than attempting to cage infested tips at these places, thus eliminating the possibility of liberating other pests that might not be present in these areas. Later on, after the parasite is established, it might be feasible to transfer infested tips from these original plantations to other isolated plantings and permit Campoplex and other parasites to emerge normally from caged tips, since the fauna in these plantings is presumably similar. This parasite work resulted in the colonization of Campoplex in two plantations in Holt County in northern Nebraska with the cooperation of Mr. Watkins, and a third colony released in a plantation near the forest. The data on these three colonies are numbered in order below.

The parasites emerging from the parasite cages used in the regular rearing experiments were utilized in obtaining a supply of Campoplex frustranae. These were removed from the vials on the cages at least twice a day, the desired species segregated in the 4-inch shell vials and supplied with either water or sugar-water by saturating part of the cotton stopper. After an hour or two the Campoplex were transferred to quart

mason jars containing strips of crumpled paper and a muslin cover, and were placed in an ice box at 46° to 50° F. to prevent activity. It had been found previously that if left in the laboratory during hot summer weather most of the parasites died in a day or two. On each second day the jars were removed from the ice box for a short time and the parasites supplied with sugar-water on a piece of blotter, many of them feeding readily. From 72 to 100 Campoplex were placed in each jar. For the 699 adults accumulated in this manner for the first two colonies, over a five-day period from July 9 to 15, a mortality of only 1.1% was recorded - not counting a very few dead in the cage vials before removal.

Extension Forester Watkins arrived at the Nursery on the morning of July 15 to transport these parasites by car to the northern part of the State where they were turned over to the County Agent for release in two widely separated plantations. One lot was liberated the same afternoon, the other on the following day. In packing for transportation the parasite jars were placed in a box over ice and covered to exclude the excessive heat. This method had proved to be very successful several years earlier in transporting Campoplex to the Niobrara Division of the forest and it was found that in check jars not cooled with ice a complete mortality had occurred by the end of a day's trip. The reported number of parasites remaining alive and liberated and the location and character of the plantations is given below.

(1) A total of 361 adult Campoplex frustranae (42% females) liberated on the Merwyn French farm near Page in Holt County, Nebraska, at 4 p.m. July 15, 1932, about a half day after leaving Bessey Nursery. Legal description of land: N. W. ¼, Sec. 14, T. 28, R. 10. Plantation reported as containing 225 jack pine from 2 to 15 years old, 200 Scotch pine 4 years old, 30 Austrian pine 2 years old, and 200 ponderosa pine 2 to 4 years old. The loss

of parasites in transit was only 0.5% or 2 out of the original 363 adults.

(2) A total of 289 adult Campoplex frustranae liberated on the C. F. Adams farm near Dustin in Holt County, Nebraska, at noon on July 16, about 1½ days after leaving Bessey nursery. Legal description of land: N. W. ¼ Sec. 5, T. 33, R. 14. Plantation reported as containing 3000 jack pine 3, 8 and 10 years old; and 200 ponderosa pine 6 and 10 years old. The loss of parasites in transit amounted to 12%, or 39 out of the original 328 adults. It was reported that the muslin covering the tops of several jars had become wet by the second day and doubtless some of the parasites were caught on the wet glass.

A number of parasites remained on hand following the above introductions and later shipments to the Gipsy Moth Laboratory, and these were colonized in a private plantation near the north boundary of the forest, but a number of miles west of the planted area. These parasites had been accumulated over a 10-day period, from July 14 to 23, inclusive, were handled as above except that they were held in the 4-inch (30 x 100 mm.) shell vials with from 6 to 14 per vial. A mortality of 23% occurred during this longer period of retention, being heaviest among the older specimens. On July 23 a trip was made, in company with Forest Supervisor Nelson, to the Thompson ranch where the Campoplex were released within an hour after leaving the nursery, the box containing the vials being wrapped in wet burlap and no loss occurring in the short period of transportation. The liberation record is given below.

(3) A total of 211 Campoplex frustranae (62% females) liberated on the Thompson ranch east of Thedford, on the south side of Middle Loup River, in Thomas County, Nebraska, at about 3 p.m. July 23, 1932. The plantation forms a windbreak on two sides of the ranch buildings and consists largely

of ponderosa pine of different ages and a few jack pine, all heavily infested by tip moth. Due to a high wind considerable dispersion of the parasites was observed, and it appeared that a few dragon flies, which became active as the Campoplex were turned loose, captured a few of the adults. However, young host larvae were available for immediate oviposition and it is believed that the colony successfully established itself.

SHIPMENT OF ADULT CAMPOPLEX TO MASS.

Last winter Mr. C. W. Collins, in charge of the Gipsy and Brown Tail Moth Laboratory at Melrose Highlands, Mass., inquired about the possibility of securing a supply of the parasite, Campoplex frustranae, for some preliminary experiments with the European pine shoot moth, Rhyacionia buoliana, which is becoming a serious pest in the New England States. Later, in a discussion with Mr. Collins and Dr. Craighead, it was decided that small shipments should be undertaken in the summer of 1932, such as could be made along with other field work, and that only adults of this parasite should be transported. The Gipsy Moth Laboratory offered to supply a type of small parasite shipping box that had been devised for such work - described more fully below. These boxes had been successfully used in transporting adults but as far as personally known the shipments were of Braconid parasites which are not particularly active. It was felt, therefore, that trial shipments of the more active Ichneumonid parasite would be well worth undertaking even as an experiment in long distant transportation.

The reared adults for these shipments were held in ice boxes, at temperatures ranging from 46 to 52° F., and were fed every second day as has been described above. On the day of shipment they were transferred from the 4-inch shell vials to the boxes. Since it was known that toward the end of the emergence period only female Campoplex would be obtained, an

additional collection of tips had been made earlier and held in cold storage to prevent the issuing of early males until a few days prior to shipment, thus insuring a suitable proportion of each sex. The parasites were accumulated only over a three-day period before shipping and the loss during this time was nearly 10 per cent, part of which was due to the injury of some individuals while attempting to transfer them into the parasite boxes.

A brief description of the small parasite shipping boxes will illustrate the principle upon which they were constructed. Made of half-inch boards the box measured inside approximately 6½ inches long by 4½ inches wide and 2½ inches deep. The top was of cardboard, sliding in grooves from one end, with a small cellophane window 2½ by 1½ inches in size. A large corked hole in one end served as a means of transferring the parasites from the vials into the box with the aid of the attraction of light from the window. A hollow metal tube 3½ inches long and ¾ inch in diameter with a wick protruding from the corked ends, and held in the center of the bottom board by two clips, was used as source of water supply. A lump of loaf sugar was tacked to the bottom near each end with narrow strips of screen, leaving part of the sugar exposed for parasite feeding. When the boxes were received in Nebraska it was found that most of the wicks were dry, consequently, the water tubes were again filled before sending the parasites.

The first shipment was made on July 19, with the maximum temperature of 100° F. in the shade. This lot consisted of three parasite boxes containing 55, 78 and 79 individual Campoplex, respectively, (66% females). These boxes were packed in excelsior in a single larger box which was mailed by parcel post the same afternoon. The shipment arrived at Melrose Highlands, Mass., the third day after mailing with a reported survival of 92.5% of the parasites - or a loss of 7.5% in transit.

The second shipment was made on July 22 and consisted of two parasite boxes, packed and mailed as stated above, containing 48 and 51 adults (55% females). The survival record upon arrival three days later was 75.8% - or a mortality in transit of 24.2%. The average survival for the two shipments was 87.1%, with three-fourths of the loss occurring among the male parasites. Some of the wicks in the water tubes were again found dry upon arrival.

It appears from the experiment that this type of parasite shipping box supplied with food and water can be used with fair success in transporting active adult Ichneumonid parasites over distances requiring several days in transit, even during extremely hot weather. If more time could have been given to the care of the parasites, the mortality might have been decreased somewhat. No check shipments were made in which food and water were not supplied.

GRASSHOPPER CONTROL

In the spring of 1932 young grasshoppers began to hatch in considerable numbers and it appeared that there would be a repetition of 1931 conditions when many young trees in the newer plantations were injured and some killed by grasshopper feeding. Consequently, the Forest Service again undertook control work, by spreading poisoned bran mash, to protect the most recent plantings. The work was started in early June this year in an attempt to destroy the insects in the early stages; however, an examination of the area later in the month showed that very young grasshoppers were still fairly numerous. Apparently additional hatching had occurred after treatment, and on several days showers following the application of the bran probably influenced control on those days. It seemed advisable, therefore, to repoison the plantations put out in April since an excellent survival was

indicated and these small trees in the open furrows would be most susceptible, and this was carried out the last of June, rather than extend control to other areas.

Conditions of infestation in the plantations differ somewhat from cultivated areas in that the grasshoppers are well distributed and in the early stages depend upon the natural sandhill vegetation with no apparent feeding on the young pine trees until the insects have developed to some extent. It would appear feasible, under such conditions, to delay control work until it was certain all hatching was completed even for a late season. Treating in the last part of June would probably serve this purpose and still provide the benefit of control before any serious injury occurred on the trees. Delaying until the last half of July would be a little late because some of the damage would have occurred by this time.

The Forest Service reported a total of 1,461 acres treated, of which 901 acres were treated twice, thus requiring material sufficient to cover 2,362 acres. The cost per acre for a single application of the bait was reported as 21.5 cents, or with the contributed time of the Ranger included 26.4 cents. Practically no grasshopper damage was found in the treated plantations and the area should be fairly free from these insects next year.

In late July population counts were made in treated and untreated areas to determine the approximate kill, the separate area treated in 1931 also being examined. Counts were made on 200 separate square yard samples in each area and the following figures show the number of live grasshoppers found for 1932.

	Average No. grasshoppers per square yard.
Check areas - untreated	7
1932 control area	1.9
1931 control area	2.8

Comparing the check counts with the 1932 control area, the population

was reduced from 7 to 1.9 per square yard, indicating a kill of 73% from two applications of poisoned bait. The 1931 treatment was still providing protection the second year for that area, the counts showing 60% less grasshoppers than found in untreated plots.

Damage to trees where no control was undertaken was less in 1932 than in 1931 even though the grasshopper population for the two years was somewhat similar. Unfavorable spring conditions in 1932 apparently prevented a general increase, and it was evident that certain destructive species had been reduced considerably, particularly the two-striped grasshopper which was prevalent in 1931. This probably accounts for the lighter damage in 1932. From these developments it is not anticipated that control will be necessary in 1933.

WHITE GRUBS

Several specimens of May beetles from the Nebraska Forest were sent to Washington for specific identification last year and were determined as Phyllophaga rugosa Melsh. The beetles had been dug from the nursery soil late in the summer of 1930 after they had transformed to adults for emergence the following spring. This species is probably the most common May beetle in the locality at present and the one producing the white grubs in the nursery, although other species doubtless occur in the region. A parasitic wasp, emerging the following spring from cocoon taken in the soil at the same time as the beetles, was identified as Elis collaris (Say), a parasite of white grubs. The tough, brown cocoons of this wasp are about an inch long, equally rounded at both ends and smooth; the adult wasp is mostly black with conspicuous yellow bands around the body. There is also evidence of other parasites attacking the white grubs, but on the whole only a small per cent of the grubs appear to be destroyed.

It was found at Bessey nursery that the May beetle has a three year life cycle. The adults emerge during the spring months to lay eggs from which the young grubs soon hatch, and in midsummer of the second year these grubs transform to pupae and then to adults, hibernating in the soil in the latter stage until the following spring, thus emerging three years after the eggs were laid. During the summer three distinct broods can be found in the soil; first, second and third year grubs, the latter in late summer being found as pupae or adults. Consequently, some adults are maturing and emerging each year. These three broods are usually designated as brood A, B and C. The adults producing brood A emerged in the spring of 1929 and the serious damage in 1930 was caused by the second year grubs of this brood which is by far the most numerous. The less abundant brood B adults emerged in 1930, brood C in 1931. Damage by first year grubs is usually not noticeable since they supposedly feed partly on decaying vegetable matter, but in the second year the grubs are larger and feed during the entire season on living roots thus making injury at this time most severe. The third year grubs feed only during the early half of the season before pupating. Damage from brood A could be expected again in 1933 if many eggs were laid in the nursery by the adults emerging the previous spring.

In 1927 there was a small area in one section of Block III of the nursery severely damaged by brood A grubs. In 1930 the infestation by the next generation of this brood was the most serious that has been recorded in the nursery, the grubs destroying about 20% of all ponderosa pine transplants and in some beds killing 50% or more of the young trees. This damage occurred again in Block III. The beetles are, of course, numerous in the grass land and more open hills adjacent to the nursery but the factors which influence egg laying in parts of the nursery in certain years are not known. In late August, 1932, D. O. Scott assisted the Forest Service

in making sample grub counts in Block III to determine the abundance of the new generation of brood A, then in the first year stage. This block of the nursery had been idle during the season, and as a result of these counts may be left idle for another season rather than be put to its normal use for transplant beds.

The 1932 analysis, as reported by Scott, was based on 17 sample plots of 4 square yards each dug to a depth of one foot. In the 68 square yards examined, 112 brood A grubs were found or an average of 1.64 per square yard, several plots running as high as 3.67 per yard. This is considerably lower than the infestation recorded in 1930 in the injured sections. The 1930 counts, made in the middle of September, from 17 sample plots covering 30.5 square yards, showed an average of 7.0 brood A larvae per square yard. One sample in a heavily infested bed had 13.4 grubs to the yard. However, had further samples been taken from sections where little or no infestation was apparent and added to the other counts the general average for Block III in 1930 would probably have been between 4 and 5 brood A grubs for every square yard, to compare with the 1.64 found in 1932. It appears that brood A is again numerous enough in this part of the nursery to cause damage if transplants were placed here in 1933. This damage would probably be fairly heavy where the grubs are most concentrated but might not be apparent in other places where the infestation is scattered even though some damage to roots occurred from feeding. There is no basis for estimating the amount of injury that might result from the present infestation but appears that it would be far less serious than the 1930 epidemic.

The abundance of brood A grubs as compared to the other two broods, from the sample counts in 1930 and 1932, is shown in the following tabulation:

Year	Per cent of all grubs found		
	Brood A	Brood B	Brood C
1930	83	5	12
1932	71	9	20

During the active season white grubs are usually found at a depth of from 3 to 8 inches. A dry condition near the surface is supposed to drive them to the moist soil below. Examinations made in mid September, 1930, showed grubs distributed between 3 and 13 inches but mostly in the 6-8 inch level. Those in the adult stage were taken at depths from 5 to 20 inches with a majority between 10 and 14 inches. For winter hibernation the grubs normally go below the ordinary feeding level, and in a few small plots dug about November 1 they were found mostly at 10-14 inches, however, a few were located anywhere from 6 to 18 inches below the surface.

WHITE GRUB CONTROL

Various control measures have been recommended at different times to reduce white grub damage but many of these are impractical in nursery practice, and in spite of the fact that these insects are commonly injurious in most parts of the country no satisfactory means of control has been found. It seems that certain methods showing promise at one place may be of little use at another place where the type of soil is different. Experiments in Nebraska have been limited by the scarcity of grubs in most years, however, in 1930 at lease one method was proven worthless and a few other preliminary tests made were not conclusive.

In the early spring of 1930 the Forest Service applied crude white arsenic at the rate of 80 pounds per acre to several transplant beds in

the nursery by mixing the material with the manure which was spread before plowing - this material had been reported as giving control in a Vermont nursery but it seems questionable if the results had been based on any controlled experiments. As it happened the crude arsenic was applied in one of the worst spots of the 1930 infestation and it was very evident that this amount of material as applied had no effect on the grubs - neither had it any apparent affect on the trees. To apply this material in much greater quantities might prove detrimental to the trees because of the amount of soluble arsenic that it contains.

After the infestation was apparent in 1930, Scott, who was working on insect problems at the time, tried some poisons by applying them in narrow trenches made between the rows of transplants, using the crude white arsenic and some old calcium arsenate that was on hand at the rate of from 100 to 500 pounds per acre on small plots. The only dead grubs found when the plots were dug were a few in the calcium arsenate areas but the per cent dead was too small to be of any significance. However, this cannot be considered a satisfactory test for the materials since they were not spread through the soil and at the time could only be applied in a narrow strip between the rows.

For control of Japanese beetle grubs the use of dry powdered lead arsenate, at the rate of 1,500 pounds to the acre and disked in to a depth of 3 or 4 inches, is recommended as satisfactory. This method has possibilities for white grub control but the effect on pine seedlings is questionable. It has been recently reported that where this dosage or more of lead arsenate was used in nurseries in North Carolina the past season it was found that the growth of the trees was stunted as much as 40%, but very little grub injury occurred as compared to untreated sections. This

material should be tried out under Nebraska conditions. One application is supposed to grub proof heavy soil for several years but it is doubtful if this would be the case in a light sandy soil where leeching is a factor. Since brood A seems to be the only one to consider here the treatment, if proven satisfactory, would be applied every third year, 1933, 1936, etc., or when examinations late the previous summer showed that this brood to be numerous and likely to cause serious damage in the second year stage.

Some preliminary tests were made with carbon disulphide as a fumigant on square yard sample plots late in the season, September 20, 1930. A commercial emulsion was used in quantities sufficient to make 14-16 ounces of carbon disulphide to the square yard. In one case the material was poured into 8 holes about 6 inches deep and the holes plugged with soil, in the other plot it was applied on the surface as a diluted emulsion. Upon digging a month later the hole method plot produced the following: 3 dead grubs and 2 dead adults at depths from 5 to 12 inches, and 2 live grubs at 6 and 12 inches. In the surface method plot: 4 live grubs at 13 and 14 inches below the surface, and it is possible that the depth of these grubs made the material ineffective. The grubs should have been brought near the surface by heavy irrigation a couple of days before application of the solution to test the methods satisfactorily. It seems that the carbon disulphide might have some value but its use would probably be limited to treating small spot infestations that appear unexpectedly after the trees have been planted.

Concerning the possibility of grub damage in Block III of the nursery in 1934, it is believed that this block could again be planted at that time without danger of serious injury to the trees even if no attempt is made to destroy the present grubs. Brood A at that time will be in the third year and the grubs will pupate in mid summer, furthermore, there will be some mortality to these grubs between now and the spring of 1934.

BARK BEETLES

The red turpentine beetle, Dendroctonus valens Lec., was again found working at the base of several Scotch and jack pine trees in 1932. Some of these trees were 6-7 inches d.b.h., a fair size for the plantations, however, it does not require a very heavy attack to girdle the base of such trees. The beetle appears to be maintaining itself in small numbers from these attacks on green trees as well as from occasional wind broken or dying trees. It is impossible to predict whether or not D. valens could develop to serious numbers under such conditions, but fortunately it has been of little importance so far.

Nearly all of the broken or dying trees, which of course are relatively scarce, in the plantations are now found attacked by Ips grandicollis (Eich) and Orthotomicus caelatus Eich., as secondary bark beetles. This is perhaps another indication that the plantations are gradually assuming natural forest conditions - entomologically speaking. The few attacks on what were apparently green jack pine probably originated from the above source, and it is also possible that these trees were already in a weakened condition. It is not likely that these beetles are developing in the slash left on the ground from pruning since practically all of the larger limbs are utilized for fuel.

In last year's report it was mentioned that only one specimen of Hylurgops porosus Lec. had been taken in the forest in 1928 and it had not been observed since. It might be of interest to note that this species was found in August, 1932, in a number of Scotch pine logs cut during the winter for pitch moth control. Some were found to have developing broods on the undersides of logs placed in piles. The beetle is considered entirely secondary. The other bark beetles were also found in some of these felled trees, including a few Dendroctonus valens larvae in one case, but none of these were numerous.

PLANS FOR 1933

Last fall it was anticipated that work on the Nebraska project for 1933 would again have to be limited to a short period of about two months in the summer. However, as plans have been altered since that time it is now going to be possible to begin this work somewhere between April 1 and 15. This plan has already been taken up with the Forest Service. There are a number of important insect events that occur in the spring months, in connection with the problems in the Nebraska National Forest, that have not been studied because observations during the last five years have been made only during summer and fall months.

One of these is the full life history of the more recent tip moth, Rhyacionia neomexicana. It has been assumed that this moth emerges at the same time as the older species, R. bushnelli, but there may be some difference. As has been discussed in this report, the introduced parasite is not effective against R. neomexicana and there is a possibility that the early history or time of emergence of the moth is a factor. If this proves not to be the case then it is likely that the parasite is ovipositing in the young larvae but is destroyed, as now assumed. The insecticide used for dipping nursery stock to destroy the eggs of R. bushnelli should be tested for its effectiveness against the eggs of the other tip moth.

It is planned to try some experiments with removing the young tip moth larvae from the leaders before any serious injury occurs. It seems that such a method might be used to protect the leaders, where not many trees are involved, and permit a more normal height growth. There is a question of how readily these small larvae can be found and eradicated and also the possibility of some larvae moving from nearby shoots to the leader.

The white grubs should be given further attention and it seems that the spring of 1933 is a favorable time to test certain control measures.

Brood A is again fairly numerous and it is hoped that enough grubs can be found to run a series of controlled plots. The powdered lead arsenate should be tried for its affect both on the grubs and the seedlings since this seems at present to be the only promising method of grub-proofing the soil. The value of carbon disulphide as a soil fumigant should be tested again if sufficient grubs can be obtained for the experiments.

The spray experiments for control of pitch moth larvae should be repeated, and it will be possible to start these at a more appropriate time of the season this year. The character of the grasshopper infestation will also be investigated late in the spring, although it is expected that no control will be necessary.

The summer and fall work, if it is possible to spend the greater part of the season on this project, would be a continuation of the previous years' studies; progress of the introduced parasite, character of the tip moth infestations in different parts of the plantations, and records from various tree plots on growth and amount of tip moth injury. The pitch moth plots this year will show the amount of infestation resulting from insects remaining in the lightly infested trees not removed in the winter control cutting operation. Data on the egg stage and hibernating habits of the pitch moth are not complete and if any time is available these could be studied, as well as habits or injury of a number of less important insects now present in the plantations.

Respectfully submitted,

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